Naval Uninhabited Combat Air Vehicles; A Strategy-to-Task Approach to System Requirements.

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Table of Contents

Tables

Figures

Naval Uninhabited Combat Air Vehicles; A Strategy-to-Task Approach to System Requirements.

INTRODUCTION

The purpose of this paper is to provide insight to the on-going decision making effort to determine what role, if any, an Uninhabited Combat Air Vehicle (UCAV) will have in the U. S. Navy. Before proceeding any further, it is important to clearly define UCAV; it can mean many things to many people. For the purposes of this paper, a UCAV must have the following characteristics:

1) It cannot carry a person,
2) It has a lethal capability and is designed for use in combat environments (it is subject to enemy fire), and
3) It can be launched and recovered multiple times without major overhaul or maintenance.

Philosophically, a UCAV is considered to be an integrated set of systems designed to assist the warfighter successfully conduct military operations in a hostile environment. This definition is consistent with the popularly held belief that the presence of UCAVs in the Navy force structure will effectively save lives, act as a force multiplier, and reduce the cost of overall Navy operations.

The pages that follow describe some of the initial work on UCAVs done within the Naval Air Warfare Center. They start with a summary of some initial investigations into UCAV weapons systems, and follow with a report on a Strategy to Task analysis conducted to understand how a UCAV might expand the current capabilities of the Navy warfighting structure, and the system requirements necessary to provide those capabilities.

The Strategy to task approach is a top down analysis which starts with the overall National military strategy and how the U.S. Navy plans to meet its responsibilities. From there, the study focuses on current and future Navy missions and the force structure necessary for meeting those responsibilities. This information is used to derive the warfighting capabilities necessary to fulfill its mission, and finally these warfighting capabilities are examined to understand the system requirements that enable a Naval UCAV to achieve the necessary warfighting capabilities.

BACKGROUND

In 1991, a missile technology study was initiated with the goal of evaluating the potential benefits of improvements in the various component parts of the missile, such as the fuse, guidance, propulsion, warhead and seeker. Wargames were conducted at the Naval Air Warfare Center, Weapons Division to explore the benefits of new and fanciful missiles in a scenario involving political strikes against a moderately defended high value target. Nothing conclusive came out of the games but the interactions between the analysts during and after the games revealed an interesting conclusion. It became clear that the biggest constraint on the weapon system effectiveness was not any particular characteristic of a missile. It was the fact that the required strike aircraft had a man in it. The possible consequences of the loss of a man in this scenario was driving tactics and weapon deployment to such an extent that almost nothing else mattered. More than once, an analysts comments included things like: " since the new aircraft systems were so automated anyway, why is the man there at all?" Also there seemed to be a consensus that the missile designs were pushing up against the limits of physics in all directions. The design of the aircraft was limited by the fact that it carried a human. Discussions on what

would be required to achieve the same level of capability of an aircraft / weapon system without the presence of a pilot followed. Existing UAVs already embodied some of the technology necessary and previous weapons programs such as Tacit Rainbow had some of the targeting and control capabilities which would make a UCAV effective.

This effort spawned more work in the area. Two golloe-on efforts provided considerable insight into where the Navy might benefit from a UCAV, and the characteristics of such a system; these were the Highly Maneuverable Lethal Vehicle (HMLV) Study and the Joint Semi-Autonomous Air Weapons System (JSAAWS) Study.

The Highly Maneuverable Lethal Vehicle (HMLV)

Analysts took these findings back to ONR and received funding to further explore the concept an Unmanned Combat Air Vehicle. Again, the goal was to gain an understanding of the technologies that would be necessary to make such a system viable and effective.

To accomplish this, many different missions were hypothesized and evaluated using wargames. These missions included air to air missions such as airspace denial and strike escort, attack of soft surface targets such as Tactical Ballistic Missile (TBM) launchers and patrol boats, boost phase intercept of TBMs, and forward fire control or support. The conduct of these missions during the war games was used to test the relative importance of a variety of system capabilities. Those capabilities investigated included:

- Semi-autonomous target detection, discrimination, and engagement
- Semi-autonomous / autonomous route planning and navigation
- Reusable
- High maneuverability
- Self protection
- Carry inexpensive, short range systems
- Jam resistant data links
- Air refuelable

From a warfighting perspective, a first order evaluation of potential missions using wargaming indicated a weapon with these capabilities could have significant advantages. First, the absence of a human would mean no risk of POWs, MIAs, or KIAs. Second, the absence of human control requirements would enable such a system to patrol for long periods of time without degraded performance and still react quickly to time critical targets. Third, it was hypothesized that its high maneuver and self protection capability could provide high survivability. Further, the absence of pilot support systems and the high survivability suggested that these attributes could contribute to a reduced cost for conducting air warfare.

From technology perspective, the analysis suggested that the air-to-air missions should be considered first because they were technically simpler. The development of sensor technology and the computer processing necessary to detect potential targets, identify and prioritize their importance, and upon real-time authorization either prosecute specific targets, or continue to collect and refine the data available for such decisions, was the most difficult of the technologies.

In addition to these studies, there was an effort to analyze maneuver performance and the use of counter measures to increase survivability. It was learned that survivability in the face of all but the most sophisticated anti-air missiles would require 15 G maneuverability with a 25 G per second onset. The most sophisticated would require maneuvers *and* countermeasures such a IR decoys or barriers.

An analysis of potential weapons revealed that a gun would provide formidable lethality in most cases but it had survivability flaw. If the gun system is bore sighted with the UCAV, requiring it to fly directly at the target to achieve a high Pk, and if the target is

defended by a co-located anti-air gun, no amount of maneuverability can stop the UCAV from having to fly directly through the outgoing rounds. The HMLV analysis suggested that a missile system similar to a Hellfire could provide the same level of lethality (or even more) and would allow for sufficient standoff to eliminate the threat of the co-located anti air gun system.

In addition to studying maneuverability and lethality, this study looked at some notional airframe designs, engine requirements, sensors and costs.

Joint Semi-Autonomous Air Weapons System (JSAAWS)

The HMLV effort was followed by another Naval Air Warfare Center, Weapons Division study into the usefulness of a lethal, unmanned combat air weapons system. The analysis began with the basic construct of an unmanned, re-usable weapons system capable of semi-autonomous decision making, both in terms of flight controls and navigation, as well as target prosecution. This effort, however, started by investigating mission roles, notional operational concepts, and general requirements which fit within the existing and proposed Navy force structure.

One premise of this study was that a UCAV would have to provide a cost effective option for Navy missions. Thus the first step of the analysis was to work with the Naval Strike Air Warfare Center (NSAWC) and other aspects of the operational community to establish the more important missions and needs the Navy must address. These discussions with NSAWC, the Commander in Chief, Atlantic Fleet (CINCLANTFLT), Commander in Chief, Pacific Air Fleet (AIRPAC), as well as information gleaned from documents of CINC priorities (First 30 days of a SWA conflict) indicated that Suppression of Enemy Air Defenses (SEAD), Close Air Support, and Battlefield Air Interdiction (CAS/BAI to be the most critical missions. In addition, NSAWC specified that there was a critical need for Fire Support of Special Operations Forces and within the urban environment. The goal was to be better able to successfully attack extremely well defended targets and hard to kill targets.

In terms of capabilities, the operational community indicated the following as critical:

- flexibility to retarget
- positive combat ID
- ability to override / positive control
- limit collateral damage
- provide organic jamming capability
- ability to engage targets of opportunity

This study developed a notional concept of operations which consisted of using a UCAV as a very low flying, nap of the earth navigating, maneuverable air frame capable of delivering highly accurate ordnance from a close in position. The notional UCAV carried a bore sighted gun that would deliver multiple rounds against a target. By flying nap of the earth, the UCAV could survive the surface to air missile threat, and its presence would drive threat radars to be active thus making them vulnerable to anti-radiation missiles.

As with the HMLV, part of this analysis included determining the maneuverability required to eliminate the effectiveness of anti-air gun systems. It was found that 5G maneuvering was sufficient to eliminate the threat of anti-air gun systems with first order targeting solutions and perfect tracking. The JSAAWS examination of a co-located gun system diverged from that conducted under the HMLV program. Even when the gun system was co-located with the UCAV target, this study found the density of the bullets insufficient to threaten the survivability of the UCAV. This was predicated on the UCAV releasing weapons while flying through the release point rather than flying a straight vector towards its target during weapons delivery.

This analysis also included cost analyses which suggested that a JSAAWS could be more cost effective than both one way weapons and manned aircraft. This was based upon the following:

(1) Lower R&D costs; much of the technology required for this concept is already developed and that costs would be more focused on integration issues,
(2) Lower Manufacture costs; there would be no need for pilot support systems in the airframe,
(3) Lower cost per kill; the weapons employed by the JSAAWS are simple and inexpensive and the JSAAWS is highly survivable. And,
(4) Lower Operations and Support costs; unlike aircraft, JSAAWS could be stored until they are required, and operators could possibly train and maintain proficiency through the use of simulators.

As UCAVs, both the HMLV and JSAAWS are evolutionary systems rather than revolutionary ones. As was stated earlier, pieces of these systems can be found in Tacit Rainbow and existing UAVs such as Pioneer. But there have been tremendous gains since the inception of these systems. Tomahawk real time re-targeting is providing expanded capabilities in the arena of decision-making and target recognition, as has LOCAAS. Global Hawk and Dark Star programs have incorporated new C4SI technologies. What remained to be demonstrated by these efforts was a demonstration of a clear and unequivocal need for these systems within the Navy's warfighting structure. The initial phases of such an analysis were the focus of the Strategy to Task Analysis.

STRATEGY TO TASK

Evaluating the need or utility for a UCAV system is the subject of this analysis, currently being funded by the Office of Naval Research. The starting point for this analysis is developing an understanding of the current and perceived future roles of the U. S. Navy and worked from there. From there, it evaluates the most promising UCAV missions and using this data, catalogues the implied operational capabilities. This, in turn, is used to enumerate the characteristics and metrics which describe these operational capabilities and from there the analysis derives system requirements.

U.S. National Military Strategy and the Role of the U.S. Navy

The role of the Navy is being shaped by both the ongoing Revolution in Military Affairs and real world events. Our National Military Strategy has responded by specifying three tasks of the U. S. Military: (1) Shaping the international environment, (2) Being prepared to respond to a full spectrum of crises and, (3) Preparing for an uncertain future. Joint Vision 2010 has each service developing its own unique capabilities. And the Navy publication, Vision...Presence...Power, states the key to the Navy's success in preventing conflict and ensuring stability and peace is Forward Presence. Such a presence would allow for appropriate and timely crisis response. Taken together, these policy documents show the Navy challenge as being the ability to act decisively, in conditions of uncertainty both in terms of the quality of the information about the battlespace, and the after-the-fact ratification of any taken actions. Crisis response requires decision making when there may not be adequate intelligence about an advisory's intent or capabilities. This translates to unclear rules of engagement, which can lead to the problem of uncertain ratification. Only after the action will public reaction be known and with it, a clear picture of the United State's interests and objectives.

Even with a clear knowledge of the Navy's role, a battle commander must have more information. He must be able to translate this role to clear objectives, and from there

to specific missions, and beyond that to tasks, to which assets can be allocated. It is only with a clear understanding of this can the utility of UCAVs be evaluated.

Tracing Objective from Navy Roles

The Navy has a role to play in achieving the foreign policy necessities of the United States. As a military force, it translates these foreign policy needs into broad operational objectives. These are:

- Show of force - Rapidly and obviously respond to a crisis with a credible force.
- Operations in a hostile environment - Support friendly ground forces trying to achieve a non military objective, such as noncombatant evacuation operation (NEO) or peace keeping, in a hostile environment.
- Support of ground forces in combat - Support friendly ground forces trying to achieve a military objective by engaging enemy forces in combat, generally known as CAS.
- Inflict damage - Attack the enemy's infrastructure with the intent of inflicting damage to achieve an objective, either military, economic, or symbolic.
- Neutralize air defenses - Attack the enemy's air defenses with the intent of rendering them ineffective in anticipation of a conflict or as part of a campaign.
- Engage enemy forces - Directly engage enemy forces that are trying to achieve an objective such as invading a country and occupying a city or moving to a combat zone.
- Maritime enforcement - Control maritime traffic and protect it from sea and land based threats.

In reality, however, knowing this does not provide enough guidance to start moving ships and sailors. These must be translated into military objectives. This is accomplished through planning exercises within the context of the Naval Planning Scenarios. The current and future military objectives are envisioned by the Navy planners by studying and playing out scenarios based upon Major Theater Wars (MTW), Regional Conflicts (RC) including maintaining open Sea Lines of Communication (SLOC), and Military Operations Other than War (MOOTW). Regardless of the scenario, Naval forces are required to accomplish their foreign policy objectives by successfully meeting a core set of military objectives. Within the context of a MRC, Naval forces will be expected to participate in halting an invasion, destroying supply lines, conducting deep strikes against critical infrastructure targets and high value military targets (weapons of mass destruction), and neutralizing against air defenses. The LRC scenario requires the Navy to support amphibious landings, reduce the threat of Theater Ballistic Missiles (TBM) and anti ship missiles, stopping enemy reinforcements, mine clearing, eliminating threats from ships and submarines (Anti-Surface Warfare (ASUW) & Anti-Submarine Warfare (ASW)), as well as those missions that are part of the MRC scenario. The Navy's participates in MOOTW by having a lethal presence and being prepared to prevent hostile and aggressive acts against friendly forces or civilians. Table 1. Relates the Navy Planning Guidance Scenarios to the operational objectives.

Translating to Military Missions from Objectives

These military objectives are achieved by the successful execution of missions. Though they may vary in intensity and scope, all of these objectives are accomplished through the application of basic missions: Surveillance and Reconnaissance, Close Air Support (CAS), Interdiction, Suppression of Enemy Air Defenses (SEAD), Strike, Anti-Submarine Warfare, and Anti-Surface Warfare (ASUW), Mine Warfare, and Anti-Air Warfare. The execution of each of these missions can be accomplished by employing a

Table 1: Navy Planning Guidance, Missions and Foreign Policy Objectives

Navy Planning Guidance Scenario And Missions	Operational Objectives
Military Operations Other than War	
Military presence	Show of force
CAS for evacuation of forces (NEO)	Operations in a hostile environment
Regional Conflict, Sea Lanes of Communication	
Destroy antiship missile and TBM launchers	Inflict damage
CAS for amphibious assault	Support ground forces
Stop reinforcements (interdiction)	Engage enemy forces
Deep strikes against infrastructure and WMD sites	Inflict damage
Strike against air defenses	Neutralize air defenses
Anti Surface Warfare	Maritime control
Anti submarine Warfare	Maritime control
Mine clearing	Maritime control
Major Theater War	
Halt invasion (interdiction)	Engage enemy forces
Destroy supply lines (interdiction)	Engage enemy forces
Deep strike against infrastructure	Inflict damage
Strikes against air defenses	Neutralize air defenses

variety of assets. The choice is dependent upon the specific results required and the defining operational capabilities. The relationship among Navy Planning Scenarios, military objectives, and the associated missions is illustrated in Table 2.

Table 2: Potential UCAV Roles in Achieving of Military Objectives

Military Objectives	Naval Planning Guidance Scenarios		
	MOOTW	RC-SLOC	MTW
Show of Force	NEO		
Close Air Support	NEO	Amphibious assault	
Interdiction		Stop reinforcements	Halt invasion
Strike		Destroy TELS	Destroy targets
ASW/ASUW		Reduce ship threat	
SEAD	Locate/jam/avoid	Locate/jam/avoid/kill	Locate/jam/kill

Before proceeding with a translation of missions to the associated tasks, it is important to look a little closer at the Navy's involvement in Military Operations Other than War. As will be shown, it is an ever increasing activity and should play a significant role in UCAV development.

A recent study by the Center for Naval Analyses indicated that between 1975 and 1991 there have been 77 contingency events that might have or did result in hostilities. And since 1990 there have been over 75 contingencies in 84 months, most of which occurred with less than two weeks warning. As can be seen from Table 3, the majority of operations were not initiated with becoming involved in hostilities as a forgone conclusion. The events broke out as follows:

- More than half of the crisis responses were of a standby nature.
- About a third of the responses (30%) did not include carriers though they did have LHAs or LSTs (50% of NEO Operations and Maritime Control were done without carriers)
- Only 9 out of the 77 responses (12%) resulted in hostilities
- The most frequent events were Support of Ground Forces, Maritime Control, and Non-combatant Evacuation Operations.

Table 3: Number and Type of Naval Operations

(January 1975 - January 1991)

Nature of Ops	Active	Standby
Show of Force	17 (5)	4 (0)
Peace Keeping	2 (0)	NA
NEO	4 (2)	14 (8)*
Supporting Ground Forces	5 (1)	19 (3)
Inflict Damage	1 (0)	NA
Neutralize Air Defenses	1 (0)	NA
Engage Enemy Forces**	1 (0)	NA
Maritime Control	6 (3)	4 (1)

* In 5 standby ops, evacuation occurred by other means

** Desert Storm

() = when no CVs were present

The number of MOOTW events (conservatively estimated as the combined Show of Force, Peace Keeping, and NEO operations -- 23 of 37) represent the majority of time and effort spent by the U.S. Navy. This suggests the Navy must seriously consider these types of operations when evaluating its future role, and this means a rethinking of the operational capability development process. Traditionally, Navy needs have been developed through evaluation of MRC requirements. It answered the question: "What does the Navy need to win the war?" However, planning for a Major Regional Conflict does not necessarily provide the capabilities needed for other operations such as Lesser Regional Conflicts or Military Operations other than War. This is because many aspects of Naval Operations are governed by elements other than military necessity. For example, the possibility of POWs resulting from a Naval operational task can be unacceptable for diplomatic reasons, but not from a military standpoint.

In addition to the strategic thinking and planning, the CINCs are assessing their ability to meet current challenges. The Operations Directorate of the U. S. European

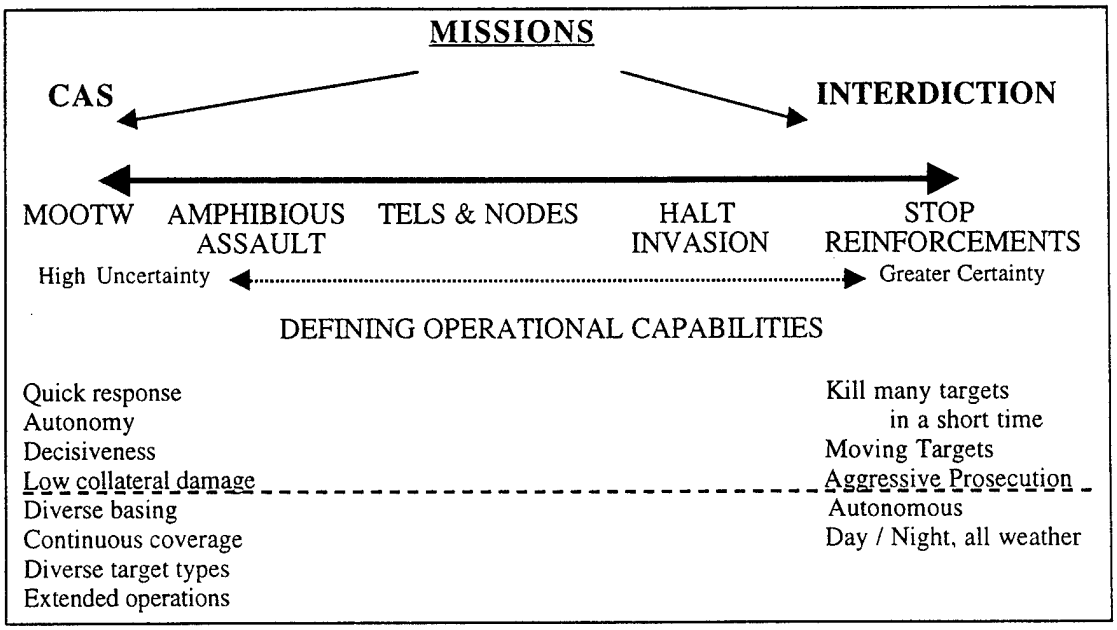
Command recently concluded that there is a high priority need for increased reconnaissance and surveillance capability. This was based in part, on the amount of information required to conduct the increasing number of peacekeeping and NEO operations.

All of this suggests that the Navy should consider tasks associated with Military Operations Other than War as it plans for its future operational capabilities and force structure. Its systems and structure should facilitate the cost effective execution of its actions in support of MOOTW.

WARFIGHTER CAPABILITIES AND CHOICE OF TOOLS

The success of any of the above mentioned missions requires a wide range of capabilities. During MOOTW operations, quick response and minimizing collateral damage are critical to mission success. MTW operations require the ability to kill many targets in a short time and bring massive fire power to bear on enemy forces. Figure 1 illustrates this.

Figure 1: Continuum of Operational Capabilities



To meet these requirements, the Navy can use a variety of tools or systems. It can use manned aircraft equipped with short range weapons. These must rely on some degree of tactics, Electronic Counter-Measures (ECM), and even stealth for the survivability of the aircraft and the success of the specific mission. Another possibility is to use manned aircraft with long range standoff weapons. The choice between these systems will be based on the threat to mission success, the importance of minimizing collateral damage, and the consequences of mission failure. The Navy can also look to surface launched weapons systems instead of manned aircraft. Current capabilities include both long and short range systems capable of single or multiple kills per missile.

If we look to the future, we can also foresee the availability of both hypersonic missile and UCAV systems to meet these challenges. Whereas the capabilities, strengths and weaknesses of surface launched missiles, manned aircraft and their associated weapons is understood, this cannot be said of hypersonic weapons and UCAVs. Before evaluating the relative benefits of all the aforementioned tools, some basic attributes and CONOPS associated with Hypersonic weapons and UCAVs must be assumed.

Ongoing hypersonics development suggests that such weapons would travel at speeds averaging about Mach 5 to 6 and would have ranges comparable to a Tomahawk missile. It would have a moderate-to-large warhead, and as a weapon system would be designed to destroy hard or deeply buried fixed targets, as well as time critical (short dwell) targets.

At this point, it is important to reflect back on the work done on the HMLV and JSAAWS. These analyses indicated that such a system would be capable of being launched and recovered from a variety of facilities; carriers, destroyer and cruisers, beachheads, and land bases. Operationally, these systems could be sent beyond the operating area of ground forces to provide real-time critical information of hostile forces. This information would include identification and location of potential targets. Such a UCAV could also carry offensive weapons capable of killing a variety of both fixed and mobile target types, as well carry systems able to render radars and communications systems ineffective (i.e. jammers). These attributes would facilitate continuous coverage and quick response against a variety of targets; also important MOEs. Also, as the previous analyses found, such a system would have lower unit costs and lower operations and support costs.

With a basic understanding of the tools available of the Navy of the future, a first order comparison is possible. Again, the choice of system to use is dependent upon the mission element considered, and the effectiveness of that system in meeting required results. Truthfully, we must go beyond the military issues and return to foreign policy objectives. Thus before choosing a system, a clear set of Measures of Effectiveness (MOEs) must be established for each foreign policy objective and these MOEs must blend foreign policy needs and military operational needs. A set of MOEs was selected, based upon meetings with the operational community such as the instructors as NSAWC and MAWTS. These MOEs were mapped onto the operational objectives established early in this analysis. This is presented in the Table 4 below.

Using these MOEs, some of the relative strengths and weaknesses of the tools available become clear. Manned aircraft are one of the choice tools for a show of force, however when operations in a hostile environment are required - where losses, POWs and MIAs are unacceptable - these are not the optimal choice. In such operations, the UCAV might be the tool of choice. Hypersonic and Cruise missiles are excellent choices when neutralizing air defenses and destroying infrastructure are the goals, but they do not have the same sense of "presence" when the goal is a Show of Force. And these weapons do not have the ability for a low level measured response if the Show of Force evolves into a need to support ground forces or the need to inflict minimal damage. Table 5 suggests which of these system might best be used within the context of the foreign policy objectives the Navy will be likely asked to achieve. The addition of a UCAV to the list of assets available to Naval forces clearly contributes in the ability to achieve two of the operational objectives. When conducting Operations in a Hostile Environment, one requirement is to not exacerbate a tense situation by having KIAs, MIAs, or POW. Reconnaissance and surveillance flights with a UCAV rather than manned aircraft can be conducted for long periods of continuous coverage without such a risk. The Navy also will have an enhanced capability to Engage the Enemy with UCAVs as part of their force structure. The combination of high kill per sortie capability, the reduced demand on mission planning assets, and real time BDA will contribute to accelerating the rate and the efficiency at which targets are killed, thus potentially shortening the conflict. UCAVs provide enhanced capabilities to the Navy when its operational objective is Support of Ground Forces. Since UCAVs can be operated from ships other than carriers and from land, the Navy can support ground forces with airborne assets with less than a Carrier Battle Group. This will increase the Navy's flexibility.

Table 4: Navy Missions and Measures of Effectiveness

MOE / OBJECTIVE	Continuous Presence	Measures Response	Quick Response	Quick transition to combat	No fratricide	No MIA, KIA, POW	Coordinated air space	High sortie rate	High kill per sortie	High overall Pk	BDA capable	Effective against soft & hard and soft targets	Effective against stationary and mobile targets	Diverse basing	Long range/ endurance	All weather - day/night	No Collateral Damage	Minimal mission planning	Decreased workload of ground element
Show of Force	X	X	X			X								X				X	
Operations in hostile environment	X	X		X	X	X		X											
Support ground forces		X					X				X	X	X				X		X
Inflict damage								X	X		X				X	X			
Neutralize enemy air defenses			X							X					X	X			
Engage enemy forces							X	X	X			X	X			X		X	

UCAV DEFINING CAPABILITIES AND SYSTEM REQUIREMENTS

At the core of a UCAVs strength at contributing to the Navy's mission success, and thus achieving foreign policy objectives, are its unique capabilities. It is these are capabilities that make the UCAV useful addition to the Navy "toolbox" of systems. Further, these capabilities imply a set of important system requirements; requirements which will form the basis of any Navy UCAV design effort.

The first of these, and probably the most important, it must decrease the work load of the ground element. This will require a variety of systems. To accomplish its offensive missions, it must have the ability to independently find, identify, and engage targets. This should be accompanied by a BDA capability. To successfully operate within the expected force structure, the UCAV must be able to conduct its tasks with a minimal level of mission planning (or none), and a minimal level of airspace management. This would suggest collision avoidance, and autonomous flight controls geared towards deconfliction. This could be as simple as spatial and locational awareness or as complex as sensor awareness of proximal aircraft. It could also be accomplished by the UCAV able to stay within certain flight boundaries.

Second, is the ability to operate from a variety of basing. From a system standpoint, this means it should have the ability to take off and land in very confined spaces; perhaps even vertically.

Third, it must also minimize the possibility of blue on blue engagements. At a minimum this could be accomplished with a reliable IFF. More realistically, the ATR should be capable of identifying friendly assets, their location, and storing this information

for future reference. These systems capabilities will make a UCAV viable tool for CAS and interdiction. Another defining capability is the ability to respond quickly and decisively. Depending upon the mission, this could mean long endurance or it might mean a short time from "call to kill".

Table 5: Relative Value of Naval Systems in Achieving Operational Objectives

Naval System	Operational Objective					
	Show of Force, No-fly and Peace Keeping	Operations in Hostile Environment	Support Ground Forces	Inflict Damage to Nodes	Neutralize Air Defenses	Engage Forces
Aircraft with:						
Free Fall & Short Range Weapons	excellent	poor	good	poor	poor	good
Stand-off Weapons	excellent	poor	poor	good	good	poor
Missiles (one way)						
Cruise (new)	Good/ poor	poor	maybe(1)	excellent	excellent	good(2)
Hypersonic	Good/ poor	poor	maybe(1)	excellent	excellent	good(2)
UCAVs (two way)	fair	excellent	good	excellent	excellent	excellent

(1) loiter time
(2) exchange ratio

Fourth, it must be flexible and adaptable to changing Rules of Engagement. The most difficult situation is when a Show of force or a Peace Keeping operation turns hostile. A UCAV system must be flexible enough to transition from an information gathering and distribution system to a lethal system, and from a highly controlled system to an autonomous one.

And lastly, it must have the capability of attacking multiple targets with a wide variety of attributes in a cost efficient manner. This will require systems capable of attacks against more than one aimpoint and weapons that are effective against moving, stationary, hard, and soft targets. Clearly, weapons and sensors specific to the UCAV missions will require development. These can be condensed into the following list:

Autonomous flying and deconfliction
Synergetic target detection, identification, and selection
Responsive to external commands
Flexible response / target prosecution - adaptable to changes in ROE
Accurate weapons delivery
Kill stationary and moving targets

High sortie rate
Conduct BDA
Available on station (loiter time, all weather and day/night capable)
Trustworthy IFF (both air and ground)
Diverse basing

Among other commonalties, these system requirements cab be achieved by a moderate expansion of our current technologies. System currently in development such as Dark Star, Global Hawk, Retargetable Tomahawk, Predator, LOCAAS, LADAR, and JSTARS embody many of the critical technologies required.

SUMMARY

This analysis, as have previous efforts, have shown that Uninhabited Combat Air Vehicles can provide U.S. Naval Forces with the capabilities necessary to meet its missions and tasks. Additionally, it has provided some first order guidance on the system requirements implied by these capabilities. The next step is to investigate trade-offs among the system requirements within the context of UCAV employment. This will enable the Navy to understand the relative benefits of specific system requirements and capabilities and, in turn where to invest in technology growth and integration. And both of these are necessary steps on the way to designing and fielding a UCAV which will be cost effective addition to the Navy arsenal of weapon systems.

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